CARICATURING BUILDINGS FOR EFFECTIVE VISUALIZATION

A Thesis

by

GRANT G. RICE III

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2005

Major Subject: Visualization Sciences

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Approved by:

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ABSTRACT

Caricaturing Buildings for Effective

Visualization. (December 2005)

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Chair of Advisory Committee: Dr. Ergun Akleman

The objective of my research is to identify and analyze the techniques of exaggeration, simplification, and abstraction used by caricature and cartoon artists. I apply these techniques to an expressive 3D modelling process which is used to create building caricatures. This process minimizes the number of unimportant details and increases the recognizability of the buildings. Additionally, the building caricature process decreases the time spent modelling the buildings and reduces their overall file sizes. The building caricature process has been used to create other building caricatures, as well as interactive visualizations and 3D maps of the Texas A&M University campus.

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CHAPTER I

INTRODUCTION

Three dimensional (3D) environmental visualizations of built structures are very useful for a large variety of applications. They can be used as pictorial maps, teaching aids, planning tools, for public relations purposes, and interactive visualizations. These visualizations can help to inform the public about well known landmarks and the architectural heritages of cities [1]. Finally, 3D interactive visualizations help designers create collaborative decision making tools for use in community environments [2]. These tools can be used in public presentations or on-line.

Current production techniques for 3D environmental visualizations stress near photo-realism in both modelling and rendering. Figure 1 shows an example of a 3D visualization that I created with too many details. Although none of the 3D environmental visualizations of built structures can be truly accurate, this concept of photo-realism forces the designers to create reconstructions that are as detailed as possible.

In practical applications these details are not necessary. Most interactive visualizations are never rendered close enough to witness and observe every detail present on a built structure. A very detailed representation causes the hardware (on the PC platform) to take more time for real-time rendering, resulting in an unsatisfactory frame rate [3]. Therefore, designers must not try to model every detail present on the built structure. This is not an easy task. They cannot simply design “a box” by ignoring all of the characteristic features. Unfortunately, current visualization techniques do not provide a clear answer to this problem.

The thesis model is *IEEE Transactions on Visualization & Computer Graphics.*

Fig. 1. Example of a typical 3D environmental visualization with too many details by Grant Rice.

These unrealistic expectations of photo-realistic details never existed in traditional fine arts. According to Ayn Rand [4], most artists will try to create a visual abstraction of what they see. Artists isolate the essential and unique characteristics of their subjects and integrate them into a single unit. In her book, *The Romantic Manifesto*, she describes this process by referring to an apple. On pages 47 and 48 Rand [4] explains,

> No one can perceive literally and indiscriminately every accidental, inconsequential detail of every apple he happens to see; everyone perceives and remembers only some aspects, which are not necessarily the essential ones; most people carry in mind a vaguely approximate image of an apple's appearance. The painting concretizes that image by means of visual essentials, which most men have not focused on or identified, but recognize at once.

The artists perform a process of selective representation and then use different techniques to render their subjects.

Such selective representations are most noticeable in the works of caricaturists and cartoon artists. Although their techniques can vary greatly in regard to style, they ignore the unimportant details and selectively exaggerate and simplify the unique features that make their subjects instantly recognizable.

The design techniques of exaggeration, simplification, as well as abstraction used by caricaturists and cartoon artists can be applied to the production techniques for 3D environmental visualizations. Specifically, they can be directly applied to the 3D modelling process.

The goal of this thesis is to analyze the different design techniques used by caricature and cartoon artists and how they can be applied to the 3D modelling process for environmental visualizations of built structures.

CHAPTER II

PREVIOUS WORK

I will organize previous work into the following sections:

1. Three Dimensional (3D) Environmental Visualizations

2. Caricature

3. Cartoon Art

A. Three Dimensional (3D) Environmental Visualizations

With advances in technology, architectural design and rendering is moving from the drafting table to the computer. Advanced 3D modelling and rendering programs, such as Maya [5] and 3D Studio Max [6], give designers the ability to turn drawings into interactive and multimedia visualizations of built structures. The non-designer or client expects environmental visualizations instead of boring and hard-to-read construction drawings. Similarly, the movie industry desires near photo-realism in its backgrounds and scene stages. Such requests lead to an unreasonable expectation of highly detailed 3D environmental visualizations of built structures.

Designers use many different methods to aid in production techniques for modelling and rendering of 3D environmental visualizations of built structures. Most of these methods involve the collection of real world data in the form of multi-view photographs [3], detailed construction drawings, and survey data. According to Paul Debevec [7],

> They ('large visualization projects') typically involve surveying the site, locating and digitizing architectural plans (if available), and convert-

Fig. 2. Render by architecture student, Zhifeng Lin [8], for final project.

ing existing CAD data (again, if available). Moreover, the renderings of such models are noticeably computer-generated; even those that employ liberal texture-mapping generally fail to resemble real photographs.

See Figure 2.

Architectural and archeological historians use environmental visualizations to educate the public about complex heritage structures. Because their intent is to preserve and accurately recreate the preexisting heritage structures, the historians build 3D models that are very complex and consist of highly detailed texture maps. For example, a highly detailed environmental visualization of a complex heritage structure was created of Fatehpur Sikri [3], a palace structure near Agra in India. The people involved with recreating the project in 3D chose the site because of its intricate details, the availability of accurate 2D data and archaeological surveys, and the existing structures were well maintained for site study and digital photography

[3]. The resulting environmental visualization was fairly accurate, but some sacrifices to complexity had to be made to help speed up the speed and frame rate of the computer display [3].

Detailed 3D models and rendered images are unnecessary for most applications. Unless it is the goal to show magnified details, most environmental visualizations never get close enough to reveal intricate details. If the camera is moving in a scene as a virtual fly-through, the translation speed of the camera only gives glimpses and broad overviews of the scene. Interactive 3D visualizations using on-line media players such as Macromedia Shockwave Medial Player [9] or VRML, were also not intended to use highly-detailed models. According to Rakkolainen et al. [10],

> The VRML browser downloads the entire model to the user's computer even if they do not see it. The more complex the model in terms of polygons and texture maps, the greater the overall file size. This results in a much slower playback speed of the visualization on the user's computer.

If the interactive visualization displays multiple buildings, such as in these 3D pictorial maps, the models have to be even more simplified.

In figure 3 , I created a 3D model of the Administration building at Texas A&M University by combining ground-level, roof-level, and aerial photographs. The model was built in Maya [5] using these photographs as reference. See figure 4. Textures for the model were created by using the actual photographs and were mapped to the surface of the model. This creates a semi-photo-realistic representation of this existing built structure. Unfortunately, this results in a model consisting of thousands of polygons and textures with large file sizes. This slows the playback and performance of the computer for rendering and interactive visualizations.

Way finding programs, mapping software and on-line maps also offer varying

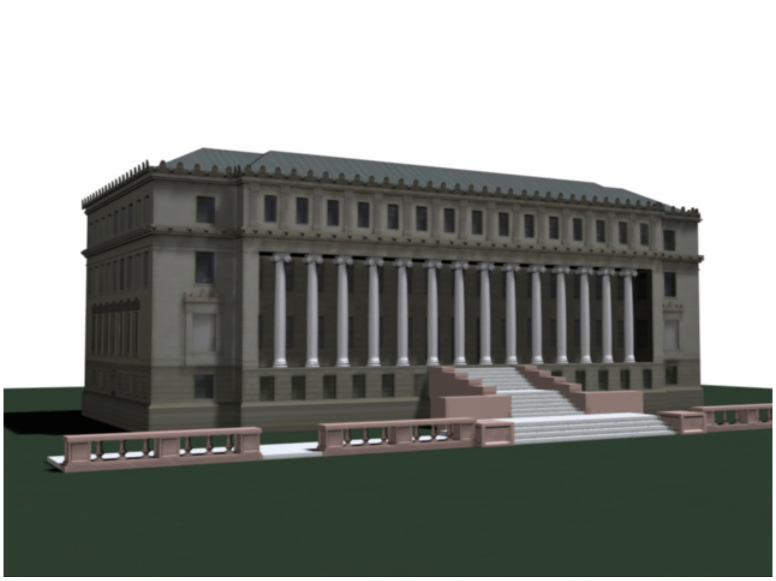


Fig. 3. 3D model of Jack K. Williams Administration Building at Texas A&M University, College Station, Texas by Grant Rice.

Fig. 4. Reference photograph of Jack K. Williams Administration Building at Texas A&M University, College Station, Texas by Grant Rice.

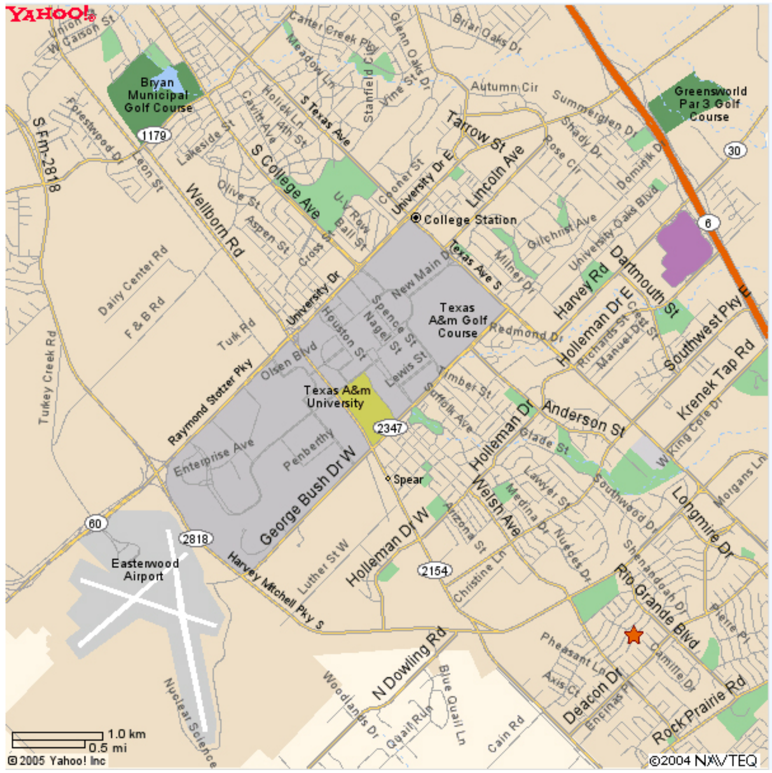


Fig. 5. Yahoo! Maps [11] showing location of a local business in College Station, Texas.

degrees of level of detail. Most do not show built structures at all. They rely on traditional hardcopy map design methods by only showing roads with labels. They use multiple colors to indicate the types of roads, parks, residential areas, commercial areas, and government organizations. These designs and layouts are very simple and can download very quickly to a user's computer with a high speed Internet connection. These simple designs are also useful for tracing driving directions from a beginning location to a destination.

An example of an online mapping application that follows traditional map design and layout would be Yahoo! Maps [11]. Yahoo!'s mapping program offers limited point-and-click functionality. It uses no 3D built structures to indicate the location of landmarks or existing built structures. See Figure 5.

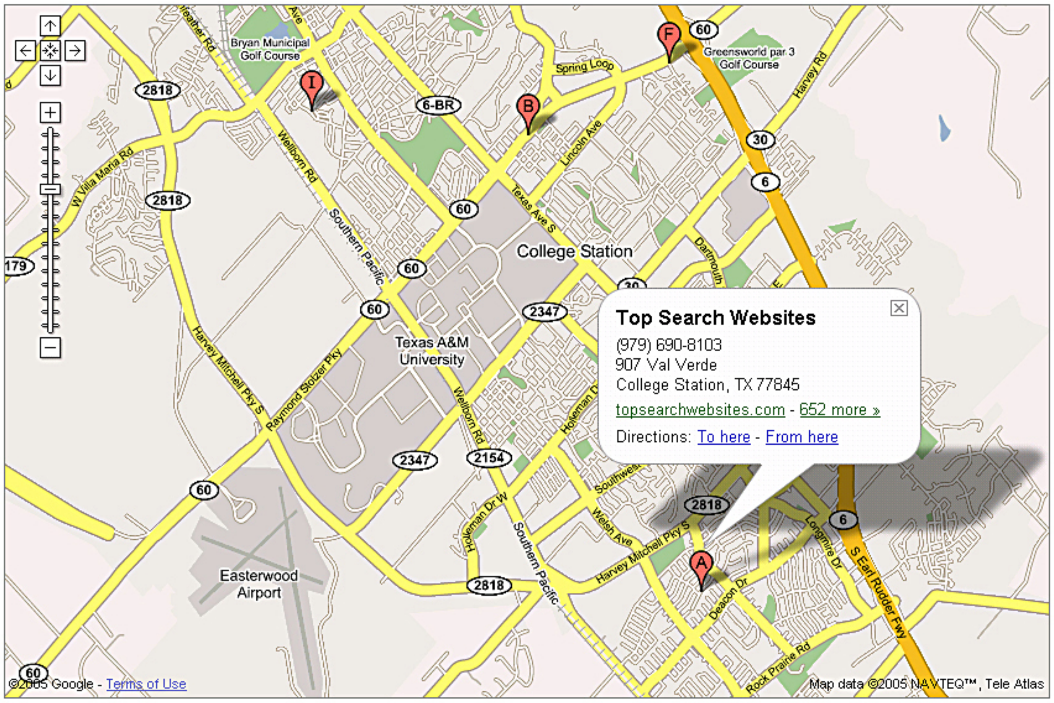


Fig. 6. Google Maps [12] location of a local business in College Station, Texas.

Another example of an online mapping application is Google Maps [12]. Google's mapping application adds virtual "thumbtack" markers onto the surface of the 2D maps. The markers are very simple and only help to identify a location on the map, much like a thumbtack would indicate a location on a traditional 2D map. The markers cast a virtual shadow to increase readability. Google Maps also allows for more user interaction than Yahoo! Maps because you can drag or pan the map by clicking and dragging with the mouse. See Figure 6.

Recently, Google Maps has added satellite imagery to their online mapping application. This is by far one of the greatest advancements towards using 3D elements on maps. By clicking on the "satellite" hyper-link, Google Maps displays the corresponding satellite image of the desired location. The same interaction is available as with the 2D Google map. The user can click and drag this version around the screen

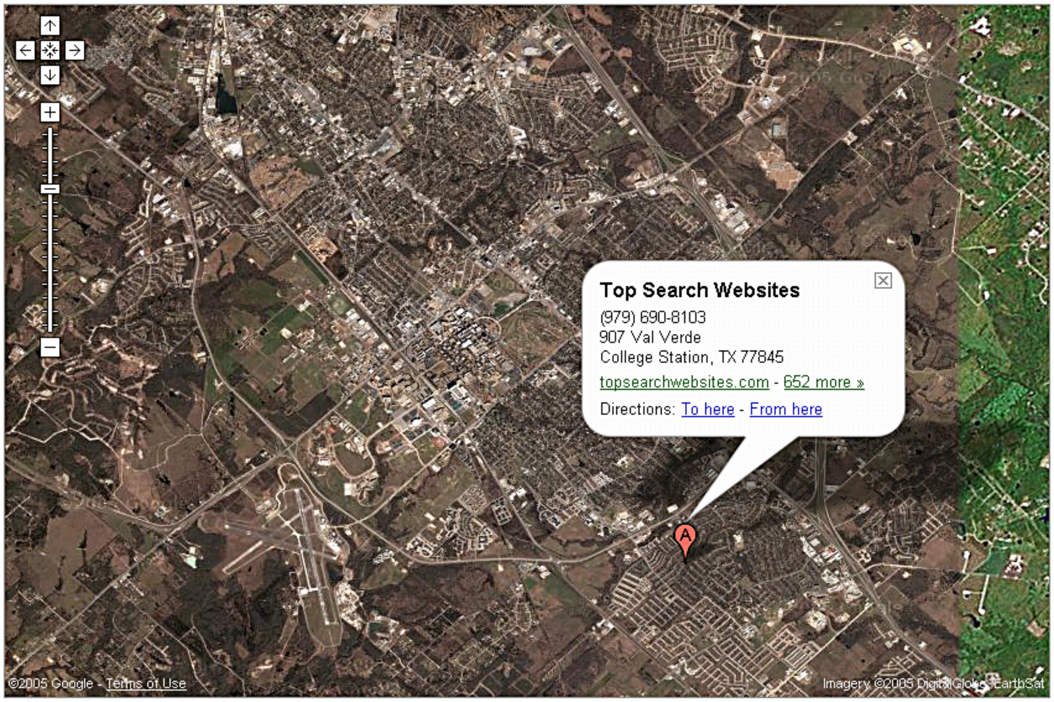


Fig. 7. Google Maps [12] satellite showing location of a local business in College Station, Texas.

using the mouse. They can also zoom in to see desired locations. See Figure 7.

One disadvantage of the satellite imagery is that not all maps on Google Maps have corresponding satellite images. Moreover, only major cities and landmarks have up-to-date or current imagery. Some satellite images can be up to 10 years old, making it more difficult to find landmarks, built structures, or roads. Another disadvantage is that Google Maps only provides a bird's-eye-view of the desired location. This gives limited and unfamiliar visual information for users. Furthermore, there is a limit to the magnification provided. This is for obvious security reasons and also because higher resolution images would require much more computer resources to transfer and display larger images. Finally, the satellite images display all existing built structures and environmental elements that existed when the image was taken. This results in an over abundance of information including small and large built structures, cars, and

Fig. 8. Google Maps [12] satellite image showing close up of Texas A&M University Campus, in College Station, Texas.

other forms of urban noise. This makes the images difficult to use for way finding. See Figure 8.

In the Spring of 2005, Google released Google Earth [13]. Google Earth is an interactive mapping application that combines the flat maps and satellite imagery of the online Google Maps with 3D mapping transformations such as pan, tilt and rotate. Users are able to create fly-throughs of existing buildings, show terrain, and view existing built structures in 3D. These 3D built structures are placed on top of the satellite imagery. Figure 9 shows a view of downtown Houston, Texas.

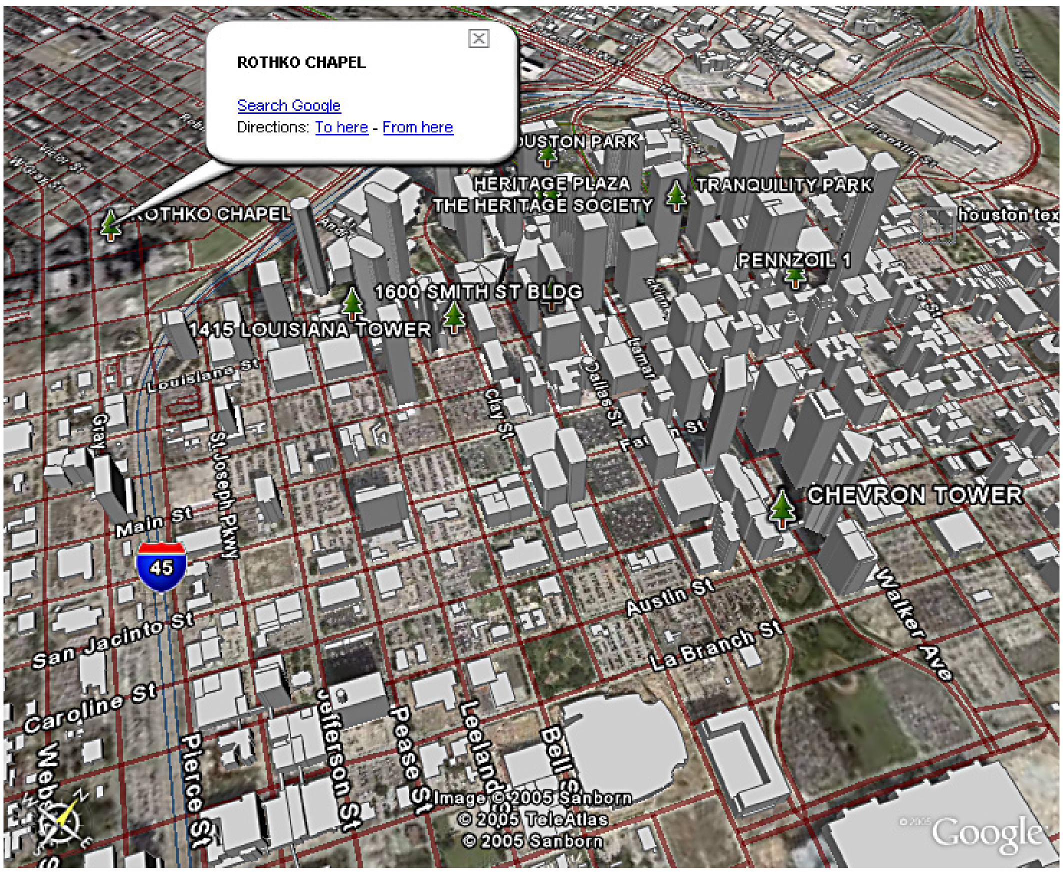


Fig. 9. Screen capture of Google Earth [13] program showing the downtown area of Houston, Texas. Parks and recreation areas are marked.

Google has simplified and reduced data within Google Earth by limiting the number of details present on the 3D representations of built structures. They also use icons to represent local hotspots such as restaurants, bars, and gas stations. This maximizes the interactive speed between the user and the Google Earth program. This also increases the data transfer speed between the user's Google Earth program and the main company Google Earth server.

Until recently, no standards exist for designing on-line environmental visualizations. Self taught designers and animators were able to transfer their CAD data as well as 3D environmental models to accessible web formats such as Macromedia Shockwave Director [9] or VRML. These on-line environmental visualizations vary greatly in complexity, level of detail, overall file size and compatibility across multiple computer operating systems and Internet browsers. To address compatibility issues, the Web3D Consortium has created a standards format called X3D [14].

According to the Web3D Consortium [14] website:

> X3D is an open standard for 3D content delivery. It is not a programming API, nor just a file format for geometry interchange. It combines both geometry and runtime behavioral descriptions into a single file that has a number of different file formats available for it, including the Extensible Markup Language (XML). It is the next revision of the VRML97 ISO specification, incorporating the latest advances in commercial graphics hardware features as well as architectural improvements based on years of feedback from the VRML97 development community.

Unfortunately, the Web3D Consortium and the X3D file format does not address the issue of how complex to make 3D models for online environmental visualizations. The question that arises is how do we simplify and reduce the information used

Fig. 10. Caricature of Bob Hope by Al Hirschfeld [16].

to recreate and present these 3D environmental visualizations? Where can we find clues to these methods of selective representation? The design techniques used by caricature and cartoon artists offer a possible alternative solution.

B. Caricature

Lenn Redman [15] defines caricature as “an exaggerated likeness of a person made by emphasizing all of the features that make the person different from everyone else” [15]. He goes on to explain that exaggeration is not a distortion. “Exaggeration is the overemphasis of truth. Distortion is a complete denial of the truth” [15].

There have been many great caricature artists over time, but unfortunately the process of caricature has not been well documented. There are very few books or publications that try to teach the caricature process. Therefore, the caricature process varies, and the design techniques pass verbally and visually throughout history from artist to artist. Redman states that the lack of information on how to draw caricature is “due to the erroneous belief that caricaturing cannot be taught-that those of us who are able to draw them (caricatures) are endowed with something special in our genes” [15].

Fig. 11. Hand sculpted 3D caricature of The Rolling Stones by artist Liz Lomax [17].

Usually, caricature artists portray celebrities and people in the news and exaggerate their features for comedic effect. The subjects are not fictional and the general public is well informed of their appearances and personalities due to widespread media coverage. Caricature artists have to be very skilled in how they represent their subjects and in the styles and methods they use to portray them.

Successful caricature artists are able to capture and exaggerate the defining bodily characteristics that make their subjects unique. "In life, we are able to recognize our friends, family members and acquaintances at a glance, but do we understand what we see in the individual that makes him instantly recognizable? Caricature artists make the following observations: Which of their subject's features are larger, smaller, sharper, or more rounded when compared to the general population?" [15].

Caricatures of famous people can be two dimensional (2D), simple line drawings or very detailed three dimensional (3D) renderings using oil paints. Occasionally, 3D sculptures of caricatures have been created and modelled out of clay. Artists, such as Liz Lomax [17], create hand sculpted, 3D caricatures of celebrities. She then photographs them in artistically manufactured environments. See Figure 11.

With advances in computer technology, caricatures have been created using computer graphics software. The main focus of computer graphics research on caricature involves caricaturing faces. Most of this work uses 2D caricatures [18], [19], [20].

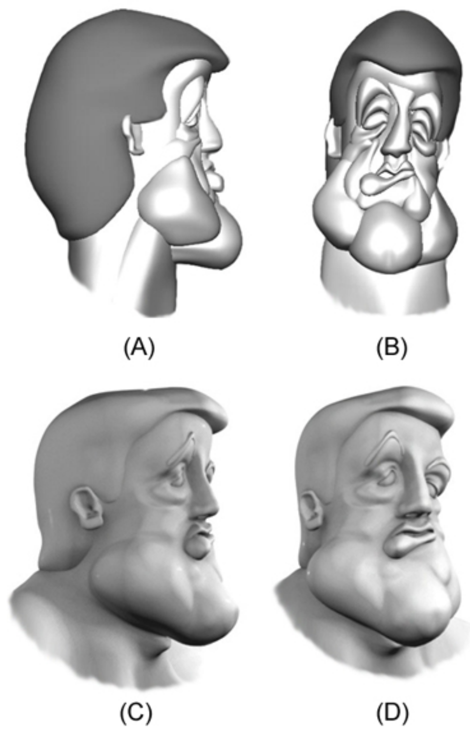


Fig. 12. Sylvester Stallone by Jacob Brooks [23] created using Akleman-Reisch method [22]. (A) and (B) show modelling with disconnected pieces. (C) and (D) show final 3D caricature.

Skaria et al. [21] developed a user interface to create 3D cartoon faces, but cartoon faces differ from caricatured faces. In cartoon faces, abstraction is more important. In caricatured faces, recognizability is more important.

Akleman and Reisch [22] recently developed a method to model expressive 3D facial caricatures. Akleman uses this method to teach students the caricature design techniques of exaggeration, simplification and abstraction. They do this by modelling expressive 3D facial caricatures. This method has been successfully implemented in a geometric modelling course that combines artistic as well as the scientific aspects of 3D modelling.

In Akleman-Reisch method [22], caricaturing faces is a process that consists of four stages: (1) Data collection; (2) Unique (Exaggerated) Feature Identification; (3)

Abstract Caricature Creation and (4) Final Modelling and Rendering . Using the Akleman-Reisch method, all students, regardless of their artistic abilities, can create convincing 3D caricatures. Figure 12 shows an example created by a student, Jacob Brooks [23].

Regardless of style, methods, or medium used, successful caricatures are not distortions or false representations of their subjects. Caricature artists emphasize features that do exist and are more noticeable when compared with a generic representation–often referred to as the ideal form. Caricature artists only exaggerate those characteristics that make their subjects unique. They often ignore unimportant details that would only add to and make their caricatures too complex or hard to recognize.

C. Cartoon Art

Cartoon art is more abstract than caricature. Cartoon art is non-photo realistic and consists of lines and solid colored fills drawn to represent a fictitious person, animal, landscape, or urban setting. If shading or tonal values exist, they are simple and not photo realistic. Cartoon artists use a very minimal amount of information in their drawings, just enough for us to be aware of the subject matter and situations represented in the art.

The subjects in cartoon art are more generic and not individually unique. For example, Preston Blair [24], a cartoon director for Walt Disney Studio, separates his characters into generic sizes and proportions to convey personalities and meaning. As described by Preston Blair, "The heavy pugnacious character has a small head, large chest or body area, and heavy arms and legs. His jaw and chin protrude" [24]. Other examples include the cute and screwball characters. All of his character's body shapes are derived from a combination of these generic sizes and proportions. When

Fig. 13. Heavy, pugnacious chicken by Michael Stanley [25].

combined, these shapes convey an easily recognizable character personality.

In an introductory modelling and animation course at The Visualization Sciences Program, Texas A&M University, students apply the design methods of Preston Blair to create 3D characters. Figure 13 shows a heavy, pugnacious chicken created by Michael Stanley [25].

Another famous cartoon artist is Guillermo Mordillo Menendez [26], known by his fans as Mordillo. He was inspired by the works of Walt Disney. As in Figure 14, Mordillo's cartoons mostly consist of one frame illustrating imaginary cityscapes and people. All modelled forms in Mordillo cartoons are generic and non specific. Similar to most cartoon art, his buildings, characters, and landscapes are made up of simple structures and forms. All shapes can be repeated to fill a scene without adding too much complexity. Mordillo's cartoons are easy to read, and the scenes portrayed are instantly recognizable.

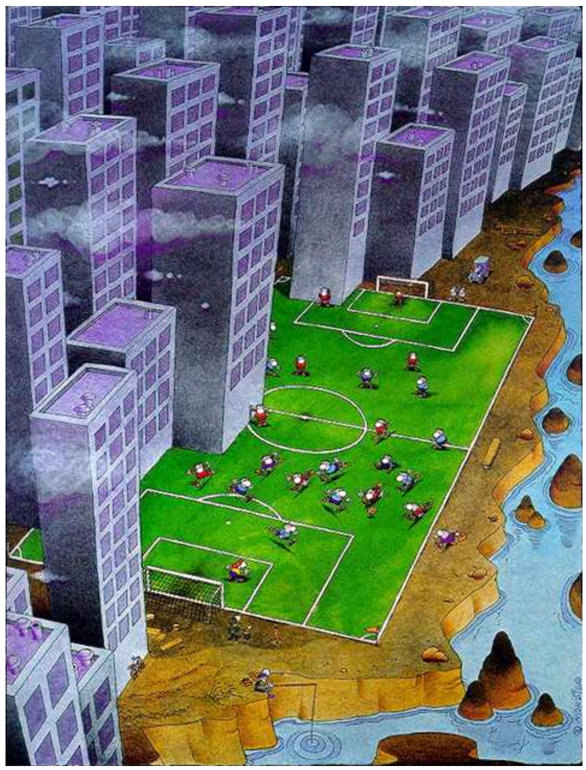


Fig. 14. Untitled cartoon by Mordillo [26].

CHAPTER III

THEORETICAL FRAMEWORK

In this thesis, I will first analyze the different design techniques used by caricaturists and cartoon artists. I will identify and analyze the techniques of exaggeration, simplification, and abstraction in these ranges:

1. Exaggeration: normalized to extremely exaggerated

2. Simplification: 1D to 3D (less to more dimensional)

3. Abstraction: representational to non-representational

Finally, I will apply these ranges in a 3D expressive modelling technique.

A. Exaggeration

In his book, "How to Draw Caricatures," Lenn Redman [15] states that exaggeration is not a distortion. "Exaggeration is the overemphasis of truth. Distortion is a complete denial of the truth" [15]. Redman goes on to define caricature as "...an exaggerated likeness of a person made by emphasizing all of the features that make the person different from everyone else" [15].

Caricature artists use varying degrees of exaggeration in their works. They simplify or eliminate the ordinary or non-unique features of their subjects. Then, they exaggerate the more noticeable features that make their subjects different from "...others of their own kind" [15]. Exaggeration involves increasing or decreasing the size of a noticeable feature when compared with a "...typical or ideal type"[15].

The typical or ideal type used in caricature refers to a subject that is average in size or shape. Lenn Redman calls this typical or ideal type the 'In-betweener' because

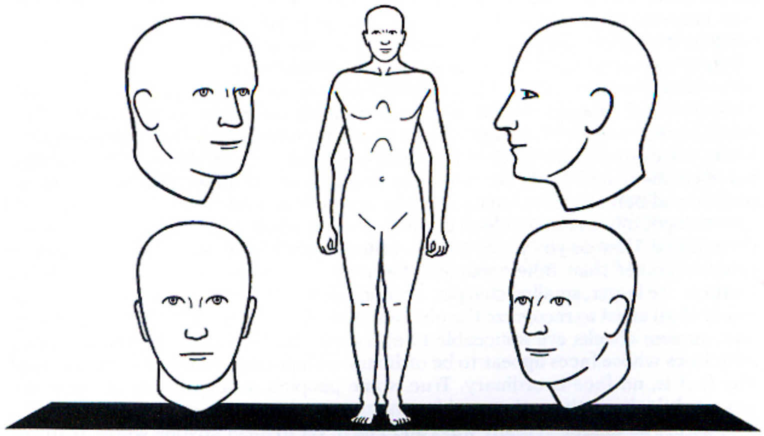


Fig. 15. “The In-betweener” by Lenn Redman [15].

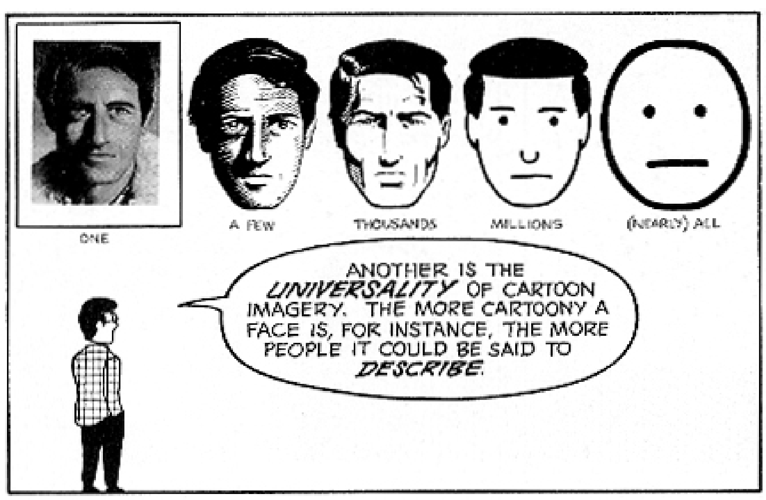


Fig. 16. The concept of “Universality” in cartooning by Scott McCloud [27].

it represents the average of all anatomical features from all people. See Figure 15.

Redman states that the In-betweener "is valuable because his construction may be used as a frame of reference for determining how to exaggerate your subject's features" [15]. Specifically, "the relative spaces between various parts of the anatomy" [15] are average or normalized. Redman's caricature technique then involves "exaggerating whatever there is about your subject that is different from the In-betweener" [15].

Additionally, caricature artists use another concept when evaluating their subject's features. Redman refers to this concept as 'Relativity in the arts" [15]. He states that "...things appear as they do because of their relationship to each other. Specifically, the relationship of things to others of their own kind, as well as things to their surrounding or abutting elements" [15].

Exaggeration can also be found in the works of cartoon artists. In his book, "Understanding Comics. The Invisible Art," Scott McCloud [27] states that "By stripping down an image to its essential "meaning," an artist can amplify that meaning in a way that realistic art can't" [27]. He goes on to comment on the concept of the "Universality of Cartoon Imagery" [27]. He states that, "The more cartoony a face is, for instance, the more people it could be said to describe" [27]. See Figure 16.

This universality is very similar to the caricature concept of the ideal type, or "In-betweener," as stated by Lenn Redman. In this thesis, I will refer to the In-betweener and Universality concepts as Normalization.

The range of normalized to extremely exaggerated appears on the proposed conceptual 'Exaggeration Scale.' See Figure 17.

Much like Redman's idea of "Relativity in the arts," the degree of exaggeration on this scale depends on two relationships:

Fig. 17. Proposed conceptual ‘Exaggeration Scale’.

1. The relationship of the subject to the normalized form

2. The relationship of the subject’s noticeable features to their surrounding and adjoining elements

For example, Al Hirschfeld [16] uses exaggeration effectively as seen in his caricature of the rock band, Aerosmith (see Figure 18). He identifies the facial and body features that make the members of Aerosmith unique and then exaggerates these features by decreasing or increasing their size relative to a typical or ideal form.

If we examine the band’s singer, Steven Tyler (see Figure 19), we notice that Hirschfeld chose to exaggerate his very noticeable and defining facial characteristics. Tyler’s mouth size, when compared with the typical or ideal human, is much larger. Additionally, Tyler’s mouth is much larger when compared with his surrounding facial features, specifically his nose and eyes.

Therefore, Hirschfeld increases the size of his mouth, specifically the size of his lips, teeth and cheeks. He also increases the distance between the mouth and nose, making the entire jaw seem much larger. Hirschfeld decreases the size of his nose and eyes and moves them closer together. These are examples of exaggeration.

The exaggerations are very effective in increasing the recognizability of the subjects. Hirschfeld removes the unimportant details and uses noticeable features. He exaggerates these noticeable details. This gives life to the drawing by not only exag-

Fig. 18. Caricature of Aerosmith by Al Hirschfeld [16].

Fig. 19. Figure (A) shows a close up of a caricature of Steven Tyler by Al Hirschfeld [16]. Figure (B) image taken by Jon Levicke [28]. Figure (C) image taken by Steve Tackeff [29].

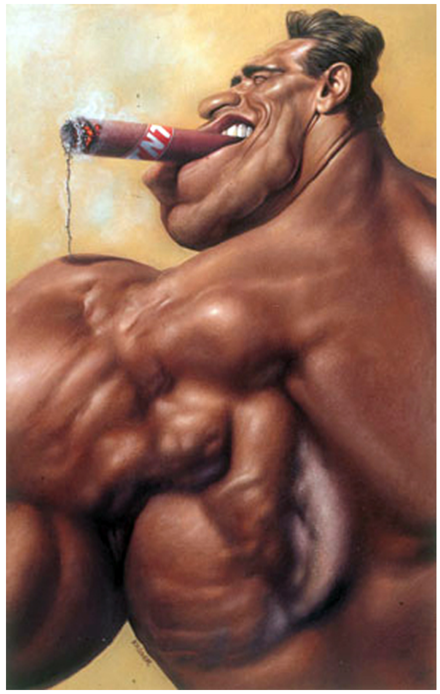


Fig. 20. Caricature of Arnold Schwarzenegger by Sebastian Krueger [30].

gerating their physical likenesses, but by exaggerating their personalities as well.

Another well-known caricature artist, Sebastian Kruger [30], uses extreme exaggeration in his works. Kruger grossly exaggerates certain unique body parts of his subjects as in the caricature of Arnold Schwarzenegger. See Figure 20.

Kruger has exaggerated Schwarzenegger's facial features by making his forehead and eyes smaller and increasing the size of his jaw. Kruger then greatly increases the size of Schwarzenegger's back muscles to add to the scale and overall muscle mass that Schwarzenegger acquired during his bodybuilding career. Kruger's caricatures are much more detailed than the works by Hirschfeld. It is his use of extreme exaggerations that make his caricatures recognizable.

An example of a cartoon artist that uses more normalized forms would be Guillermo Mordillo Menendez [26], known by his fans as Mordillo. As seen in Figure

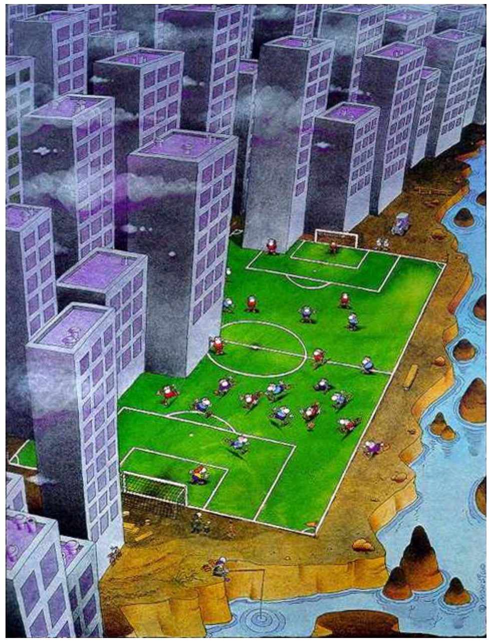


Fig. 21. Cartoon by Mordillo [26].

21, Mordillo's scenes are made up of objects and subjects that are normalized. The buildings and people are generic and could represent buildings or people anywhere.

Normalized forms can be useful to populate a scene. They create a 'canvas' from which the exaggerated subjects stand out. They should be easily repeated and only have minor differences in characteristics.

The Exaggeration Scale shows the range of exaggeration from normalized to extremely exaggerated. Exaggerating only noticeable characteristics, helps to reduce the number of fine or unimportant details. As a result, the important subjects are more recognizable to people who are familiar with them. The biggest advantage of using exaggeration in computer graphics is that much of the unnecessary and data intensive details can be reduced. "This results in an overall smaller file size for viewing 3D graphics over the Internet" [1].

Fig. 22. Proposed conceptual ‘Simplification Scale’.

B. Simplification

In Francis Ching’s book, “Design Drawing” [31], he states that “a fundamental challenge in drawing is how to convey the existence of three-dimensional objects in space by describing lines, shapes and tonal values on a flat, two-dimensional surface”[31]. Caricature and cartoon artists address this challenge in different ways. Their styles dictate whether or not their drawings appear to be flat, two-dimensional, or with volume, three-dimensional.

One-dimensional, or 1D, works consist only of lines. Two-dimensional, or 2D, works have length and width. Three-dimensional, or 3D, works have length, width, and depth. “Certain arrangements of lines, shapes, values and textures on a drawing surface, however, can trigger the perception of a three-dimensional world by our visual system.” [31]. By simplifying these arrangements or details, the artists are able to convey their content more clearly.

The varying degrees of simplification appear on the proposed conceptual ‘Simplification Scale’. See Figure 22. On this scale, simplification can range from a one-dimensional work made up of only lines to a three-dimensional work, or a form with perceived volume.

Al Hirschfeld’s [16] caricatures are simplified one-dimensional drawings with a few two-dimensional details added. As seen in his caricature of the rock band, Aerosmith

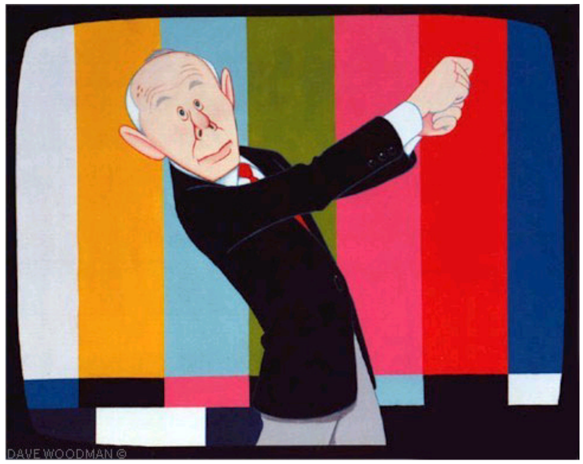


Fig. 23. Caricature of Johnny Carson by Dave Woodman [32].

(see Figure 18), he describes his subjects using only lines. The lines he uses are flowing and graceful. They are not straight or rigid. This helps to add to the illusion that these subjects are organic and alive. The caricature is indeed very flat looking, but minimal depth is conveyed by using overlapping lines which make up the various band members. According to Ching, this is referred to the "Continuity of Outline" [31]. He states that, "a shape having a continuous outline visibly disrupts or obscures the profile of the object behind it. Therefore, we tend to perceive any shape having a complete outline as being in front and concealing from our view a part of the shape behind it" [31]. The band members appear to have no mass or volume.

The addition of solid color fills to a caricature or illustration helps to reveal more information about the subject or object's surface color. Dave Woodman's [32] caricatures of famous people, such as the caricature of Johnny Carson (See Figure 23) uses this type of addition. This would be an example of 2D simplified caricature. The caricature also uses overlapping lines with varying color shades to convey minimal depth. This illusion of depth is finalized by placing Johnny Carson on top of a contrasting, colored background. This separates the foreground from the background.

Johnny Carson appears to have more mass or volume as well as depth than the Hirschfeld caricature of Aerosmith (see Figure 18).

Caricatures or cartoons cross over the threshold from 2D to 3D when artists add transitions between light and shade. As seen in the caricature of Arnold Schwarzenegger (see Figure 20), Sebastian Kruger [30] uses transitions between light and dark areas to convey shadows and highlights. His transitions are gradual which “leads to a perception of curvature and roundness” [31]. The use of different color tonal values adds to the perception of texture, in this case the texture of the Schwarzenegger’s skin. Finally, Krueger utilizes the technique of ‘Atmospheric perspective.’ According to Ching,“Atmospheric perspective refers to the progressive muting of hues, tonal values, and contrast that occur with increasing distance from the observer” [31]. In Kruger’s caricature, Schwarzenegger appears to have mass and volume. This results in the perception that he is a three-dimensional form on a two-dimensional surface.

The addition of various visual cues to add dimensionality to a caricature or cartoon greatly increases the amount of information conveyed to the viewer. Using effective dimensional simplification can result in a work that more accurately describes the subject without adding too many details.

C. Abstraction

According to the National Gallery of Art’s website [33], “Works of art that reframe nature for expressive effect are called abstract.” The explanation goes on to state that,“rather than imitate their subject’s natural appearance, some artists deliberately change it. They stretch or bend forms, break up shapes, and give objects unlikely textures or colors. Artists make these transformations in an effort to communicate something they cannot convey through realistic treatment” [33]. Finally, there are

Fig. 24. Proposed conceptual 'Abstraction Scale'.

different types of abstraction. The National Gallery of Art's website states, "Art that derives from, but does not represent, a recognizable subject is called nonrepresentational or nonobjective abstraction" [33].

The opposite of abstraction is realism. The National Gallery of Art's websites defines realism as a style of art that "...depicts subject matter (form, color, space) as it appears in actuality or ordinary visual experience without distortion or stylization" [33].

The works of caricature and cartoon artists exist in the range of realism to representational abstraction. The style and intent of the artist determine how realistic or abstract the subject is rendered. While the majority of these renderings are never truly photo-realistic, some caricature and cartoon artists use semi-realistic drawing, coloring, and shading techniques. This helps the viewer to recognize the subject or situation more easily.

The varying degrees of abstraction appear on the proposed conceptual 'Abstraction Scale'. See Figure 24.

In the caricature of John Kerry and George W. Bush by Ric Machin [35] (Figure 25), we note varying degrees of realism and abstraction. Their forms (or dimensionality) are more abstract than real because features have been altered. John Kerry's head, nose, and chin has been stretched vertically to emphasize these features present in reality. George W. Bush's head is shorter and rounder and his eyes appear small

Fig. 25. John Kerry and President George W. Bush by Ric Machin [35].

and squinted.

Machin also renders the surface colors and textures in a semi-realistic way. The surface colors are more typical of the flesh tones found on humans in reality. He uses gradations of colors to represent these flesh tones. The textures are also more realistic in the fact that they use shading, lines, and highlights to suggest a sense of three-dimensionality. Finally, the caricature has depth due to the use of shading and highlights on the surface of the subjects. Depth is also achieved by using a background image and slightly blurring this image.

Even though John Kerry and George W. Bush have been represented in an abstract manner, all pieces are still connected and continuous. This is a representational form of abstraction [33]. An example of non-representational abstraction would be the disconnected pieces of the caricature of Babe Ruth and George Bush (Figure 26) by David Cowles [34].

Abstraction in cartooning is related to the concept of the icon. Scott McCloud [27] defines an icon to mean “any image used to represent a person, place, thing or

Fig. 26. Babe Ruth and President George W. Bush by David Cowles [34].

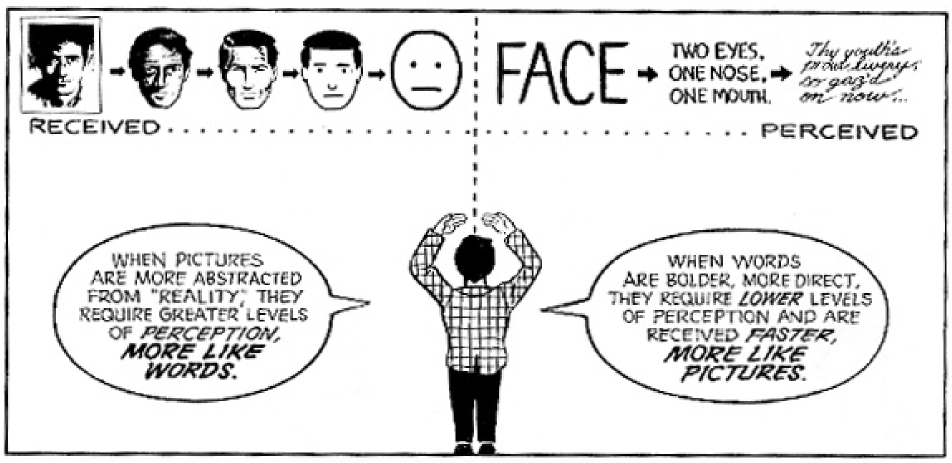


Fig. 27. The order of pictorial icons by Scott McCloud [27].

idea" [27]. McCloud states that icons can be non-pictorial or pictorial. Non-pictorial icons are usually referred to as letters, symbols and words. Pictorial icons are images that "resemble their subjects" [27]. He goes on to say that with "non-pictorial icons, meaning is fixed and absolute. Their difference doesn't affect their meaning because they represent invisible ideas"[27]. McCloud also states that "...in pictures, however, meaning is fluid and variable according to appearance. They differ from "real-life" appearance to varying degrees" [27].

McCloud puts the icons in order as shown in Figure 27. He states that "when

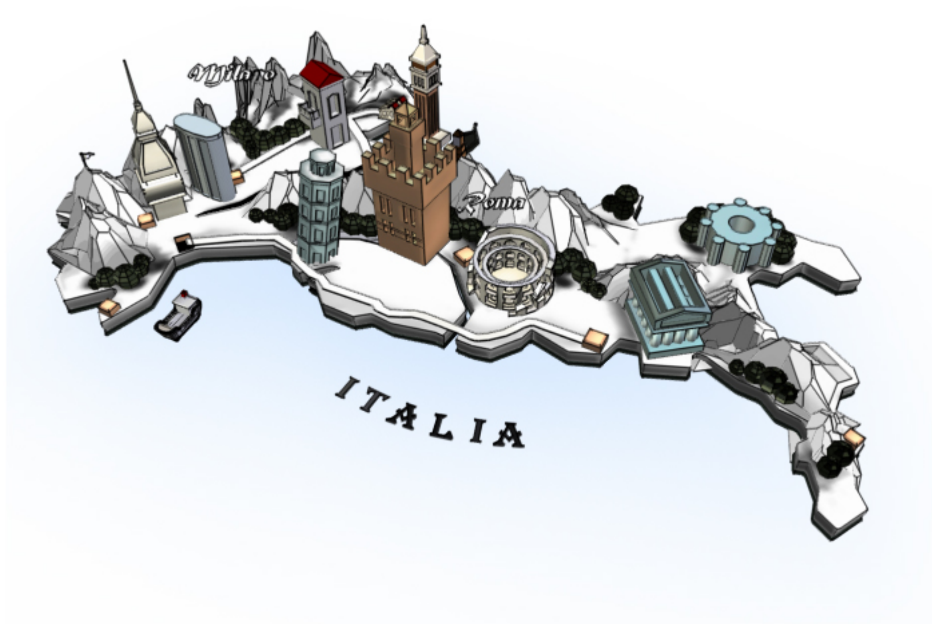


Fig. 28. Pictorial map of Italy by Asma Naz [1].

we abstract an image through cartooning, we're not so much eliminating details as we are focusing on specific details" [27]. This is similar to the way a caricature artist exaggerates only the noticeable features of their subjects. In cartooning, according to McCloud, "by stripping down an image to its essential "meaning," an artist can amplify that meaning in a way that realistic art can't." Finally, McCloud states that "when pictures are more abstracted from "reality," they require greater levels of perception, more like words. When words are bolder, more direct, they require lower levels of perception and are received faster, more like pictures" [27].

Abstraction can be very useful in environmental visualizations to reduce details and complexity. In her thesis, 3D Interactive Pictorial Maps, Asma Naz [1] uses varying ranges of exaggeration, simplification, and abstraction. Naz exaggerates the size of the popular landmarks. Naz uses three-dimensional simplification. Finally,

Fig. 29. Detail of pictorial map of Italy by Asma Naz [1].

Naz abstracts geographic and cities by using words. See Figures 28, 29, and 30.

Fig. 30. Pictorial map of Europe by Asma Naz [1].

CHAPTER IV

METHODOLOGY

Applying the design techniques used by caricature artists is challenging. Caricaturing a building is not the same as caricaturing a human face. Faces unlike buildings are topologically the same. Everybody has the same number of noses, eyes and ears. Therefore, artists achieve facial exaggerations by deformation without changing the topology. Buildings, on the other hand, are topologically different. They have a different number of windows, columns, doors, etc. Therefore, in order to exaggerate the features of buildings, we have to change the feature sizes as well as their numbers. For example, designers change the number of windows if this is a noticeable feature [36].

In this thesis, we will extend the design techniques of caricature artists to develop a method for exaggeration, simplification, and abstraction of existing built structures. This method will be used to create three dimensional models for visualization. Finally, because the techniques used by cartoon artists vary greatly, they will not be used in this method.

This method consists of four stages:

1. Data Collection

2. Identification of Unique Features

3. Building Caricature Process

4. Final Model & Rendering

A. Data Collection

A well known landmark or existing built structure is chosen. This structure can exist locally, nationally, or internationally. For this thesis, a local landmark was chosen, the Jack K. Williams Administration building at Texas A&M University, College Station, Texas. Photographs are taken from many different views to use as reference for our three dimensional building caricature of the “Administration” building.

Reference images are shown in Figure 31.

B. Identification of Unique Features

As stated in the theoretical framework, caricature artists use an average human face that has a typical or ideal shape [15]. They compare the face to be caricatured to this average human face. Since there are only a few number of features found on human faces, unique features can be identified quickly. However, buildings are much more complex and the number of unique features are not limited. Anything that makes a building interesting can be considered a unique feature. Each designer can use a different number of these unique features.

The Administration building has a number of unique features. The building's underlying form consists of a long rectangular box with a hole cut in the front of it. The unique features of this building, which are noticeable from ground level, are it's long rectangular shape, columns, windows, short roof, and ornamentation found at the top and on the facade of the building.

C. Building Caricature Process

1. Model underlying form

The building caricature process begins by modelling a simple, representative

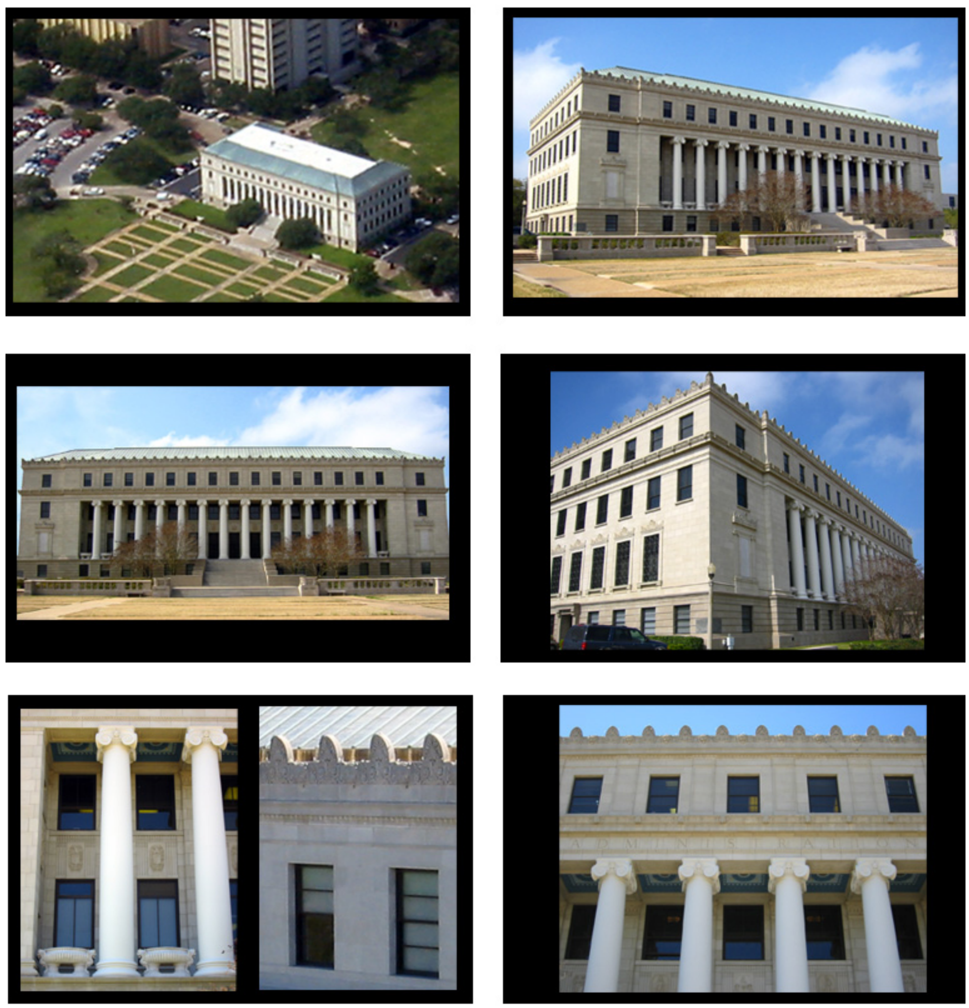


Fig. 31. Reference images of the Jack K. Williams Administration Building, Texas A&M University, College Station, Texas by Grant Rice.

shape using a 3D program called Maya [5]. A long, "rectangular" cube is modelled for the Administration building. Next, a rectangular hole is cut into the front cube face. Finally, the new face is extruded backward to reveal an opening. See Figure 32 (a).

2. Addition of unique features

In no particular order, the unique features of this building are added to the underlying form. The feature sizes and numbers are generic and will be exaggerated in the next step.

The features are added to the underlying form as disconnected pieces. Individual pieces allow for faster shape modifications and positioning. The disconnected pieces include columns, windows, stairs, roof sections, and ornamentations.

3. Exaggeration of identified unique features

One feature at a time is exaggerated. If this exaggeration creates a likeness, then continue to exaggerate. If it does not create a likeness, then exaggerate in the opposite direction. If neither direction produces a likeness, then delete this feature. This process is repeated until a likeness of the building is achieved.

The columns of the Administration building are a unique feature. Because their number is great, the decision was made to increase the number of columns located on the front of the building. The overall all size of the columns were close to the actual building proportions as shown in the reference images.

This proved to be an incorrect exaggeration and did not create a likeness. Instead, the number of columns was decreased and their size was increased. The height of the rectangular hole containing the columns was increased, and the hole's width was decreased.

Once again, these changes did not result in an instantly recognizable likeness for this feature. The decision was then made to slightly increase the number of columns

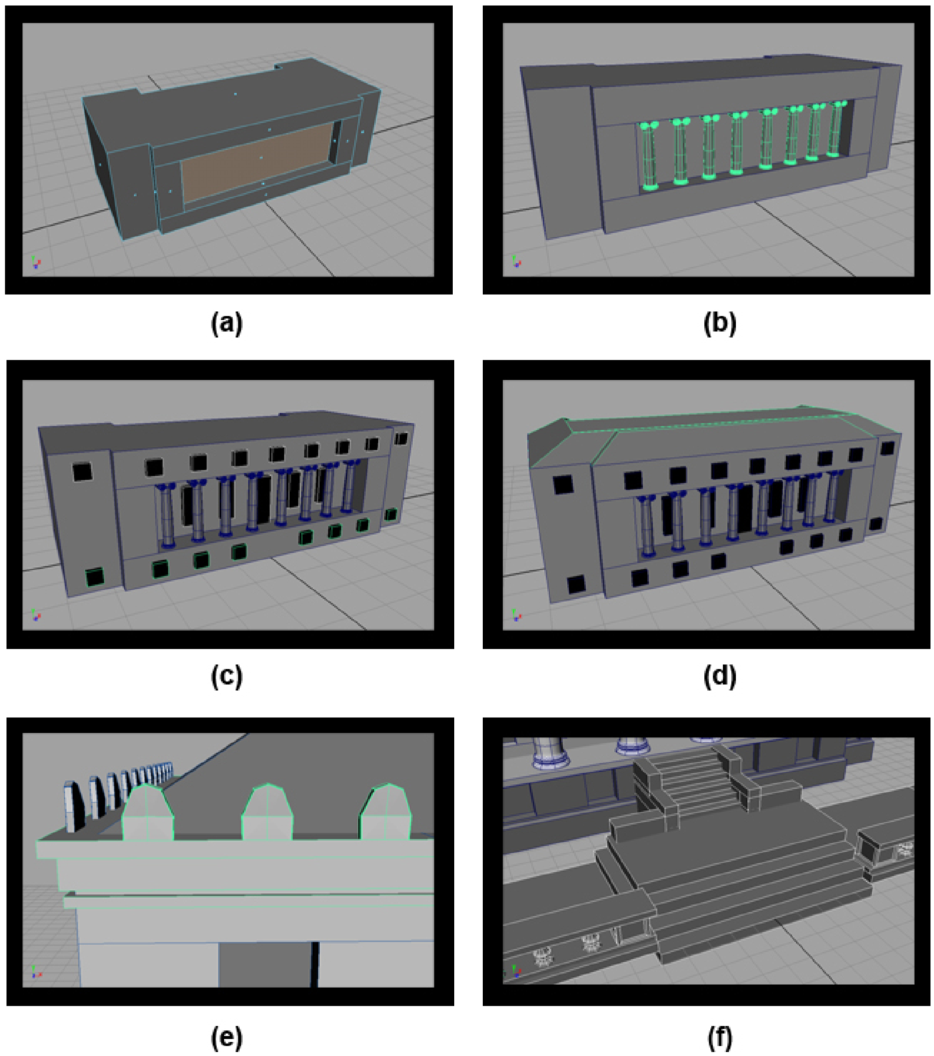


Fig. 32. Building caricature process. (a) Representative shape with hole. (b) Column exaggeration. (c) Window exaggeration. (d) Roof sections. (e) Roof ornamentation and ledges. (f) Stairs exaggeration.

and decrease their size. This resulted in a recognizable likeness with an optimal number of columns and optimal sizes. See Figure 32 (b).

The next unique feature to be exaggerated was the windows and doors. There are many windows and doors on the Administration Building. To help determine the number and size, black cubes were duplicated and pre-positioned.

The black cubes were added, removed, and resized until a likeness for this feature was achieved. The black cubes were then used to determine where to cut holes on the surface of the building. The holes were extruded backwards to reveal window and door openings. See Figure 32 (c).

The next unique feature to be exaggerated was the roof of the Administration building. The roof sections are short and "squatty." The roof sections were modelled and then added to the building caricature. Finally, the height of the roof sections was adjusted until a likeness was achieved. See Figure 32 (d).

The final unique features that will be added to the surface of the building caricature are the ornamentations. The most noticeable ornamentations include the roof ornamentations, the horizontal ledges between building floors, and the facade ornamentations.

The roof ornamentations in the reference images resemble sea shells and are numerous. To model a likeness of the shapes would require increased detail and information. Instead, the shapes of the roof ornamentations were simplified. Next, their size was increased and the number of shapes was decreased. This was done until a likeness was achieved.

The final ornamentations added to the surface of the building were the horizontal ledges and facade ornamentations. Both of these were simplified and decreased in number. In fact, some of the facade ornamentations were removed entirely. This was done because they were not as important to establishing an overall likeness. See

Figure 32 (e).

The last step in caricaturing the building was the addition and exaggeration of the front stairs. The front stairs are numerous and help to create an inviting welcome to the front of the Administration building in the reference photograph. To achieve an optimal likeness, the number of stairs was decreased and their size was increased. See Figure 32 (f).

D. Final Modelling and Rendering

Once a likeness of the building has been achieved using disconnected pieces, a final surface is created that approximates the confirmed shape. Only minor adjustments in exaggeration will be performed at this point.

The final caricature of the administration building was rendered using an Ambient Occlusion Shader developed by Jon Reisch [37]. This shader was developed for Maya, using C++ and the Maya API. The Ambient Occlusion Shader makes subtle modelling details more apparent and easier to read. This produces a clean, consistent look to the final rendered still images.

Since the shapes of the models provide the recognizability of the caricature, the number of textures and colors are limited.

Figure 33 shows the original reference image of the Jack K. Williams Administration Building at Texas A&M University, College Station, Texas. Figure 34 shows the final rendered building caricature.

Fig. 33. Reference image of the Jack K. Williams Administration Building, Texas A&M University, College Station, Texas.

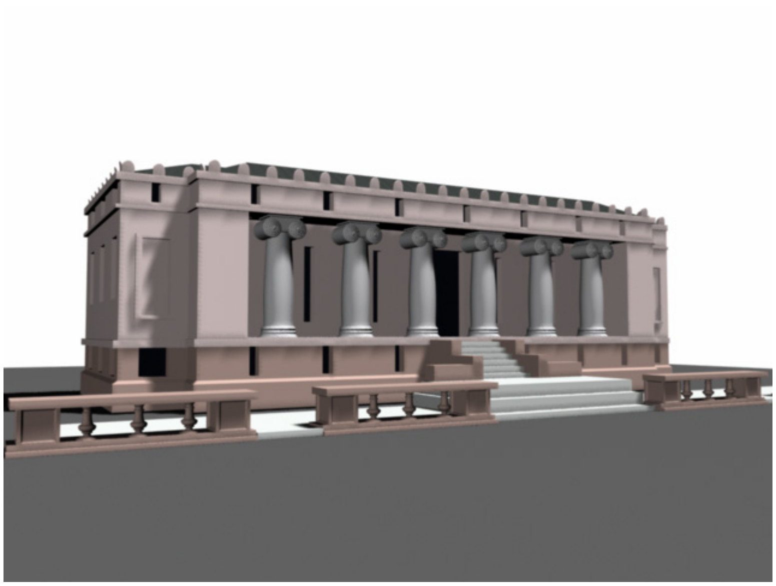


Fig. 34. Final building caricature of the Jack K. Williams Administration Building, Texas A&M University, College Station, Texas.

CHAPTER V

RESULTS

The method described in this thesis for caricaturing buildings for effective visualization has been used to create other building caricatures, as well as interactive visualizations and 3D maps of the Texas A&M University Campus. The models generated have small file sizes, resulting in faster interactive viewing on the Internet. Finally, the resulting building caricatures were easy to recognize as seen from a ground-level view.

A. Additional Building Caricatures

The building caricature method has been used to create additional three dimensional building caricatures. These buildings exist on the Texas A&M University Campus, College Station, Texas.

The first building caricature is the Oceanography and Meteorology building. This building is referred to as the O&M building. Figure 35 (a) shows the reference images of the O&M building. Figure 35 (b) and (c) shows the gradual reduction of details for the three dimensional model. Figure 35 (d) is the final building caricature of the O&M building.

The next building caricature is the Animal Sciences building. Figure 36 (a) shows the reference image of the Animal Sciences building. Figure 36 (b) and (c) shows the gradual reduction of details for the three dimensional model. Figure 36 (d) is the final building caricature of the Animal Sciences building.

The final building caricature is the Architecture building. Figures 37 (a) and (b) shows reference images of the Architecture building. Figure 37 (c) shows the three dimensional model with high detail . Figure 37 (d) is the final building caricature of the Architecture building.

B. Three Dimensional Map with Building Caricatures

A three dimensional (3D) map of the Texas A&M University main campus was created. This 3D map was created for later use with on-line interactive viewers. The building caricatures and their by-products were incorporated into this map to test the results of the building caricature method. Figure 38 is an aerial perspective of the three dimensional map with building caricatures included. Figure 39 shows a close up of the building caricature iterations on the 3D map. Figure 40 shows a close up of the high detailed model of the Architecture building and the low detailed, caricature on the 3D map.

C. Interactive Viewer for On-line Visualization

The 3D map and building caricatures, including by-products, were tested in a custom made interactive viewer. This viewer was built using Macromedia Director [9]. The resulting Director file was compiled for viewing in the Shockwave media player. The custom viewer allows for various camera selections including aerial perspective, bird's eye views, and ground-level views of the building caricatures. The camera is controlled by the user. It can zoom, rotate, and pan. Finally, the entire map can rotate clockwise and counter-clockwise by clicking a button on the custom viewer.

Figure 41 shows a screen capture of the Interactive Map of the Texas A&M University main campus with building caricature iterations included.

Additionally, the building caricatures, including by-products, were tested in the Cortona [38] VRML viewer. Figure 42 shows the high detailed version of the Oceanography and Meteorology building. Since this model and textures were highly detailed, the playback speed and interactive speed was greatly reduced.

D. By-products of the Building Caricature Method

The building caricature method takes time and practice. For this thesis, many modelling and rendering iterations were completed to create the final building caricature of the Jack K. Williams Administration building. This building is located on the Texas A&M University main campus, College Station, Texas. The final building caricature is shown in the methodology. See Figure 34.

Figure 43 (a) shows the a very early model consisting of a simple shape. File textures created from reference images were applied to the surface of this building. Even though this shape is very simple, the file size of this 3D model is very large due to the extremely detailed file textures.

Figure 43 (b) shows the same model with file textures. This model has a hole cut into the front of the building. The face has been extruded backward to reveal an opening. Columns have been modelled and added. The file size of this model increases even more due to the extremely detailed file textures and columns.

Figures 44, 45, 46 show the remaining iterations and by-products created when caricaturing the Administration building.

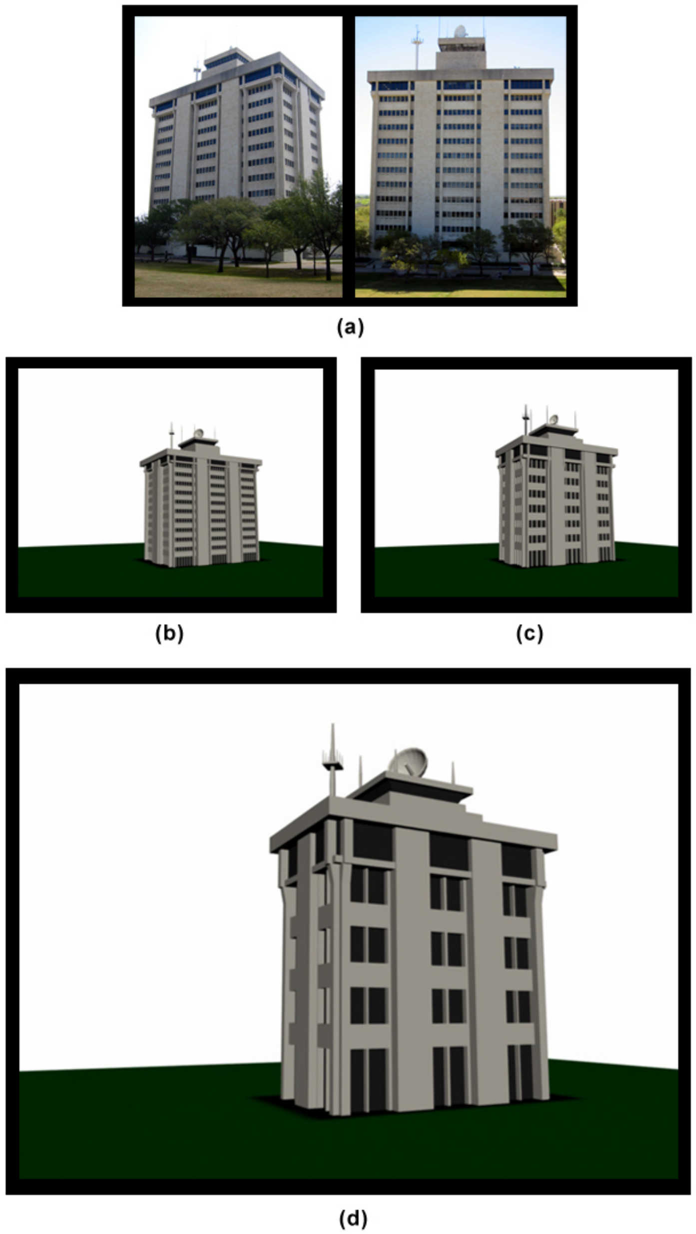


Fig. 35. The Oceanography and Meteorology Building, Texas A&M University, College Station, Texas. (a) Reference images. (b) High detailed model. (c) Medium detailed model. (d) Final building caricature.

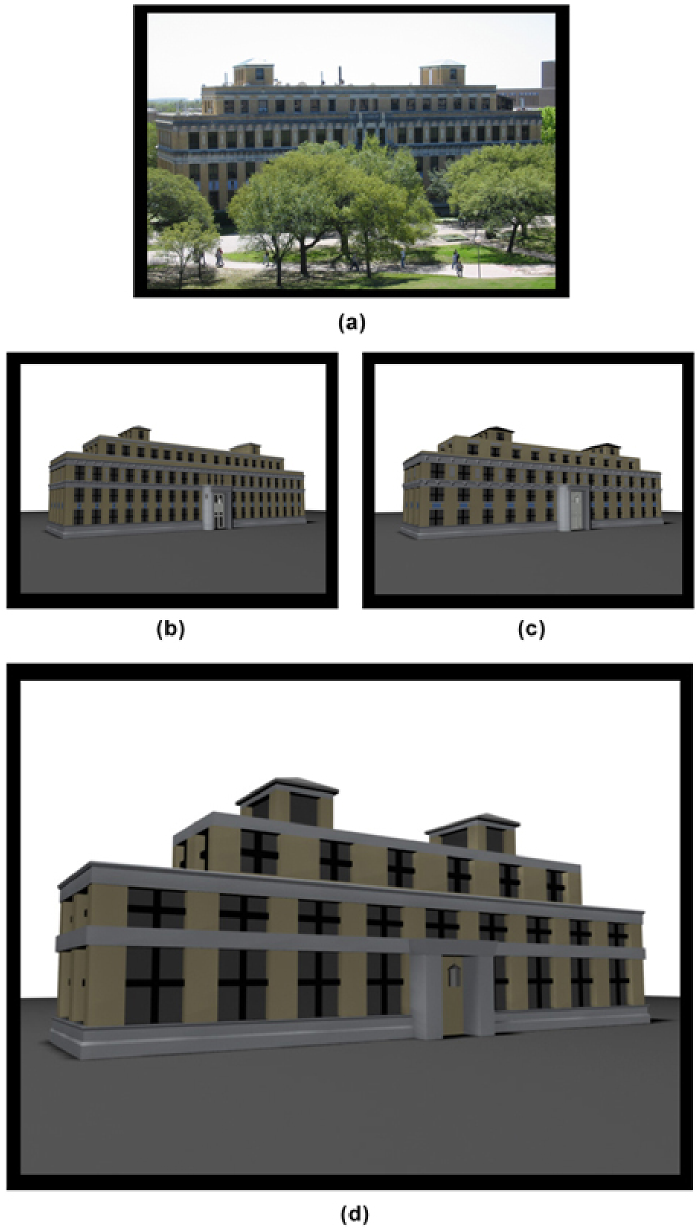


Fig. 36. The Animal Sciences Building, Texas A&M University, College Station, Texas. (a) Reference images. (b) High detailed model. (c) Medium detailed model. (d) Final building caricature.

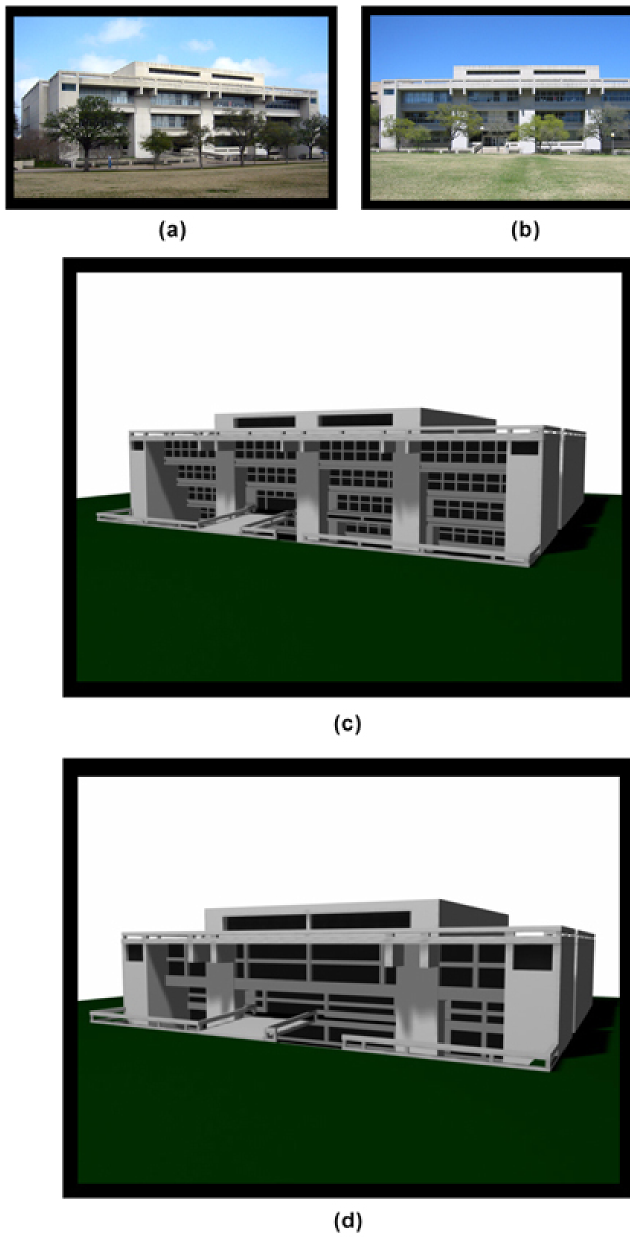


Fig. 37. The Architecture Building, Texas A&M University, College Station, Texas. (a) and (b) Reference images. (c) High detailed model. (d) Final building caricature.

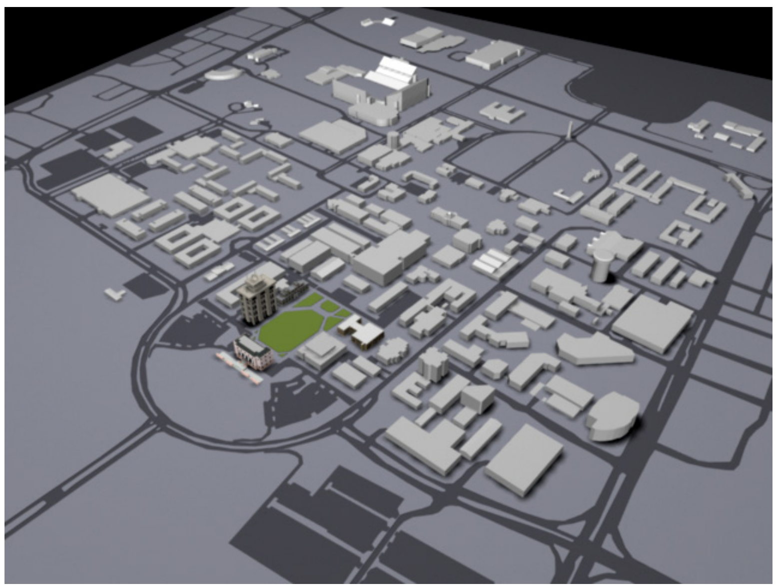


Fig. 38. Aerial perspective of 3D map of Texas A&M University main campus, College Station, Texas. Building caricatures included.

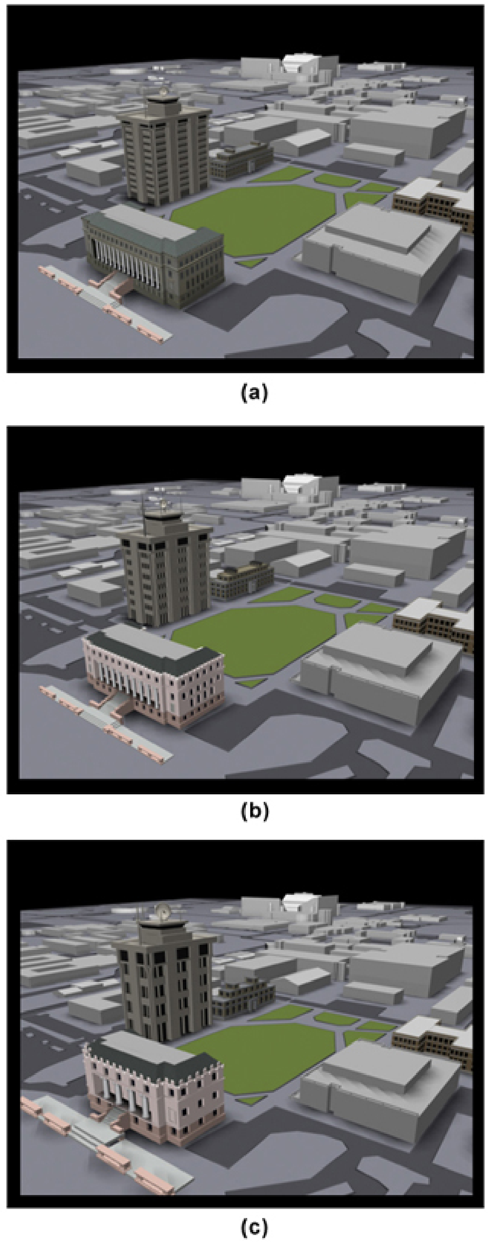
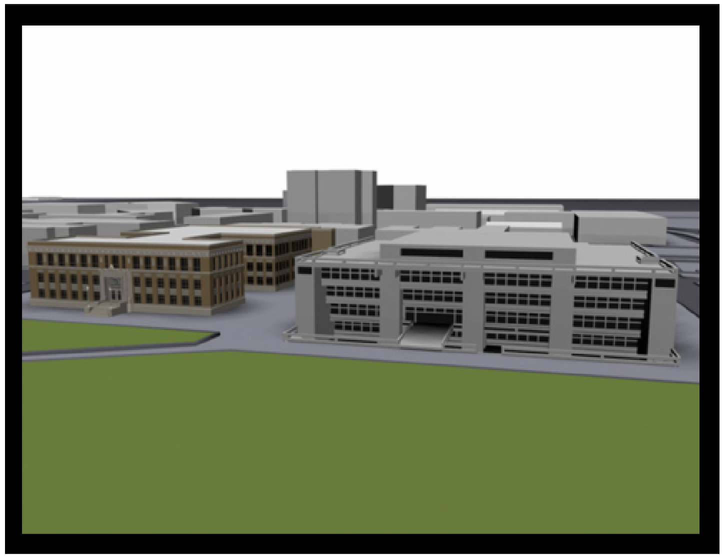
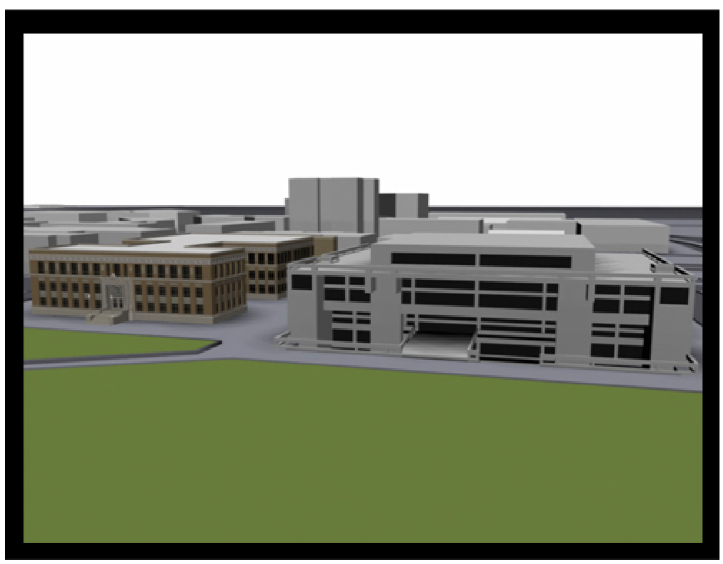


Fig. 39. 3D map of Texas A&M University main campus, College Station, Texas. Close up of building caricature iterations. (a) High detailed models. (b) Medium detailed models. (c) Low detailed models.



(a)



(b)

Fig. 40. 3D map of Texas A&M University main campus, College Station, Texas. Close up of Architecture building caricature iterations. (a) High detailed model. (b) Low detailed caricature.

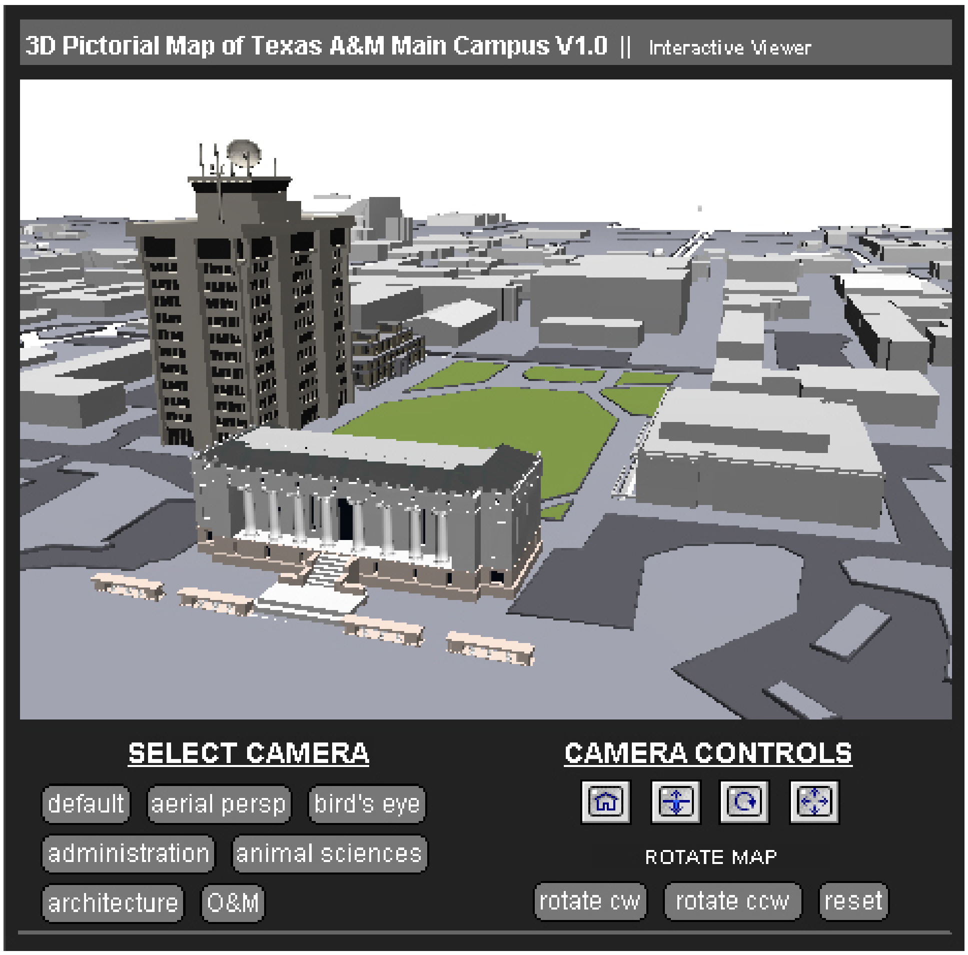


Fig. 41. Custom interactive viewer built using Macromedia Director [9] for Shockwave Media Player. 3D Map of Texas A&M University main campus, College Station, Texas. Building caricature iterations included.

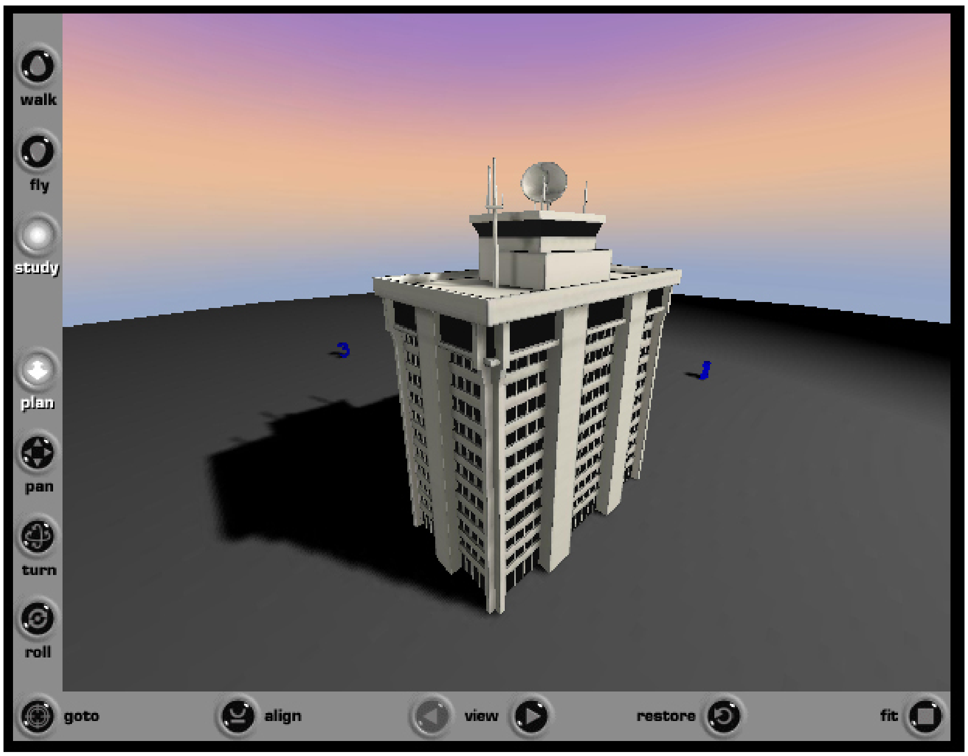
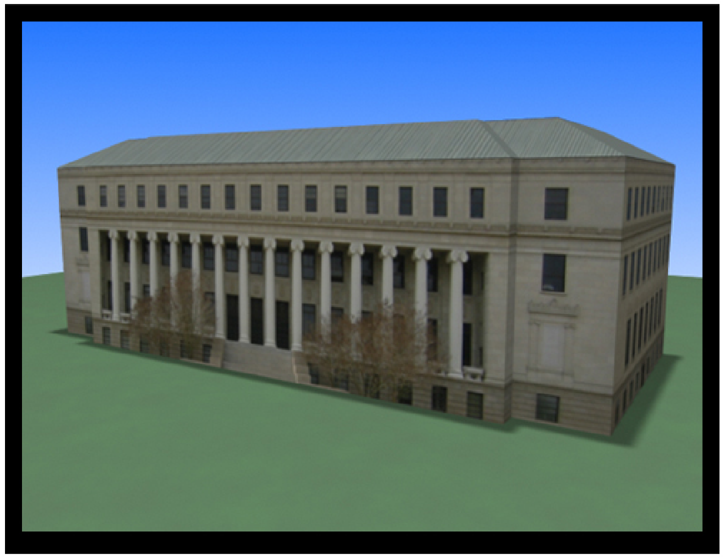


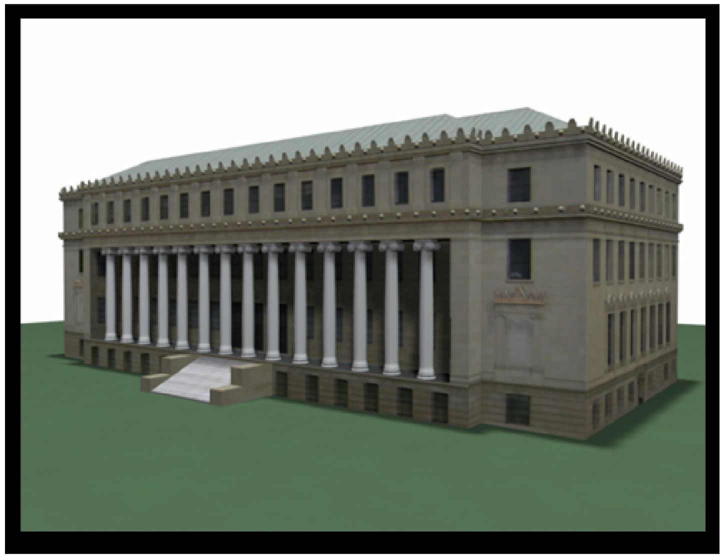
Fig. 42. Cortona VRML Media viewer [38] showing high detailed version of the Oceanography and Meteorology building on the Texas A&M University main campus, College Station, Texas.



(a)

(b)

Fig. 43. Early models of the Jack K. Williams Administration building on the Texas A&M University main campus, College Station, Texas. (a) Simple shape with high detailed textures applied. (b) Simple shape with highly detailed file textures, hole and columns added.



(a)

(b)

Fig. 44. Early models of the Jack K. Williams Administration building on the Texas A&M University main campus, College Station, Texas. (a) Addition of roof and facade ornamentations. (b) File textures removed and model rendered using Ambient Occlusion Shader by Jon Reisch [37].

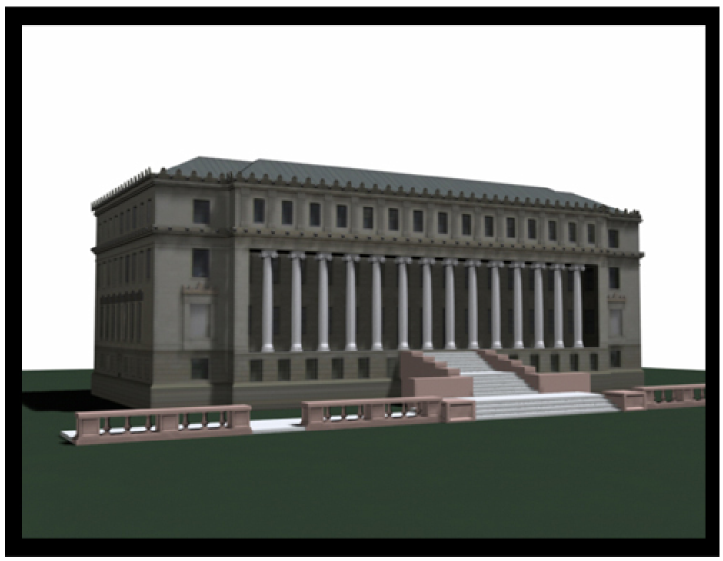


Fig. 45. Extremely detailed model of the Jack K. Williams Administration building on the Texas A&M University main campus, College Station, Texas.

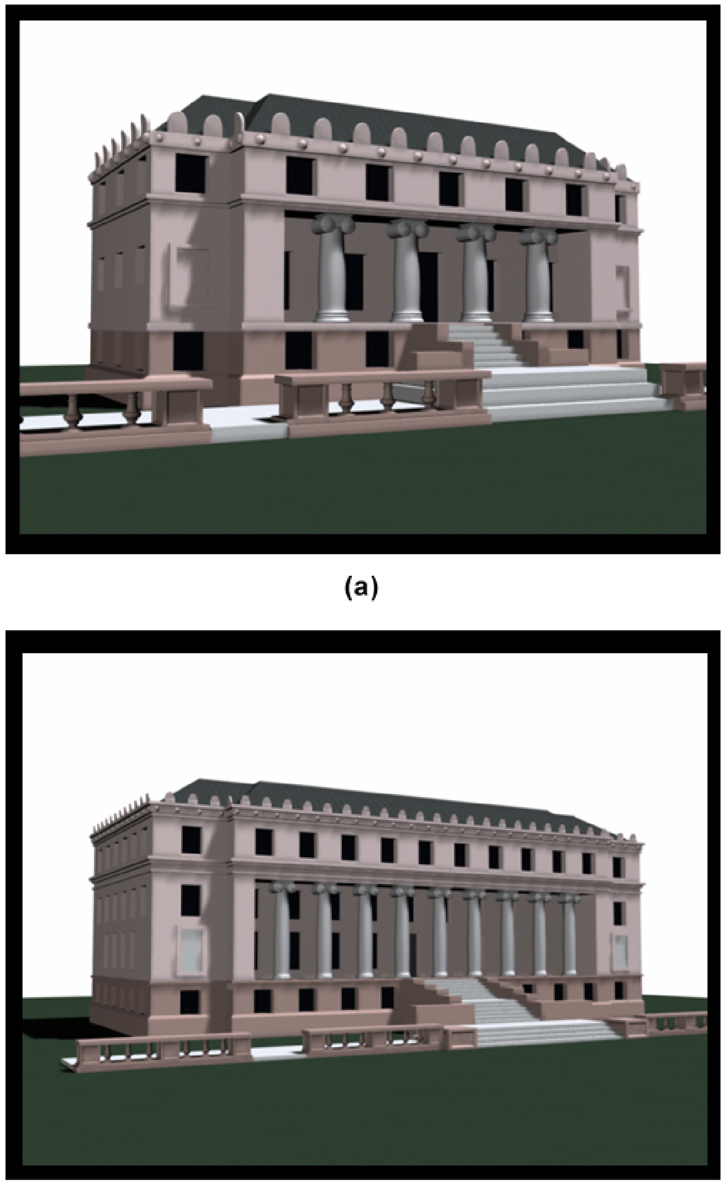


Fig. 46. By-products resulting from the caricature of the Jack K. Williams Administration building on the Texas A&M University main campus, College Station, Texas.

CHAPTER VI

CONCLUSION

The design techniques of caricaturists and cartoon artists analyzed will give designers the option of using an expressive modelling approach. The models can be used on interactive pictorial maps, teaching aids, planning tools, for public relations purposes, and interactive visualizations. These visualizations can help to inform the public about well known landmarks and the architectural heritages of cities. Finally, 3D interactive visualizations help designers visually communicate with non-designers and the public in presentations or on-line.

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